MODAS Improvements

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LONG-TERM GOALS

The development of limited-area, open-boundary, nowcast/forecast systems that have a stand-alone, shipboard capability and which can be applied around the globe, especially in shallow coastal waters.

OBJECTIVES

The Modular Ocean Data Assimilation System (MODAS) has become a Navy standard for producing analyses (nowcasts) of ocean temperature, salinity and sound speed. The objectives of this project are to expand MODAS into continuous real-time assimilation (with particular focus on data acquired by submarines) and to improve the analysis in shallow water.

APPROACH

Except for occasional submarine-launched profiles and vertical excursions, most of the temperature and salinity data acquired by a submarine consists of a continuous "thread" of data along it's flight path. Three approaches to assimilating this data are being developed. In the first approach, assimilation is done by fitting the data to a set of basis functions consisting of empirical orthogonal functions (EOFs) derived from historical profile data, years of MODAS 3D fields derived from altimetry and SST data, and fields extracted from numerical ocean models. The EOFs can be 3-dimensional, or 4-dimensional and include temporal evolution of the modes. Those derivable from historical profiles, MODAS fields, and model data could be produced on board as needed or transmitted from shore along with first guess fields using a new wavelet-based compression method developed in a related 6.4 task. Modes derived from recent numerical ocean model runs would need to be transmitted from shore, but less frequently than the daily MODAS fields which are retrieved today. The second approach will be to use a 3-D optimum interpolation algorithm where the required vertical covariances are derived from years of numerical ocean model data. Finally, since the on-board data can be provided directly as sound speed, a third approach would be assimilation into a version of MODAS based directly on sound speed, which may be more accurate (and certainly more efficient) than the present two-stage process of assimilating temperature, using that field to create an estimate of the salinity volume and then assimilating the salinity data into that field. A considerable amount of in situ data from the USS Alexandria, provided by DEVRON12, is available for evaluating these various approaches. It is anticipated that a combination of these methods will be optimal, given the limited computer resources available and fast turn-around that is required.

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14. ABSTRACT
The development of limited-area, open-boundary, nowcast/forecast systems that have a stand-alone, shipboard capability and which can be applied around the globe, especially in shallow coastal waters.

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The shallow water improvements task will be handled by a new hire who is organizing a workshop on this topic to be held early in CY2002 and which will include Navy and outside experts in this field. It is anticipated that shallow water models and measured sea surface salinities will be considered.

WORK COMPLETED

This year, the EOF-based assimilation method has been tested with several datasets from the USS Alexandria. Results to date indicate that the MODAS climatology reduces the error by as much as 50% compared to GDEMV. Using MODAS analyzed fields (produced at NAVOCEANO and the regional METOC centers) cuts the remaining error in half, and using EOFs derived from historical MODAS runs reduces that error by another factor of two. Thus even in it's present form, the EOF-based assimilation produces a field with residual errors approximately 4 to 8 times smaller than GDEMV climatology. The remaining residual errors may be small enough for a conventional 3D optimum interpolation to be successful with only approximate knowledge of the vertical covariances.

A major focus this year has been the completion of the first journal article specifically focusing on the details of the development of the MODAS climatology, including the "dynamic" climatology component which relates subsurface temperature and salinity to remote-sensed altimetry and surface temperature. The article has completed the review process and will be published in an upcoming issue of the Journal of the Atmospheric and Oceanic Technology. In addition, a general interest article on the use of MODAS was written and will appear in an upcoming special issue of Oceanography.

RESULTS

Several datasets acquired by the USS Alexandria at various locations and times of year have been assimilated using the EOF method. In these cases, the modes were derived from several years of MODAS fields in the same area and season, retaining only the modes needed to describe 90% of the variability (typically 8 to 12 modes). One example is shown in figure 1 below. The right panel displays the temperature as a function of time during a 24 hour period during which the submarine is traveling through an eddy which was not well represented in the MODAS initial field but which is clearly well-reconstructed by the EOF assimilation. The large changes in temperature represent vertical excursions (times when the submarine rises nearly to the surface).

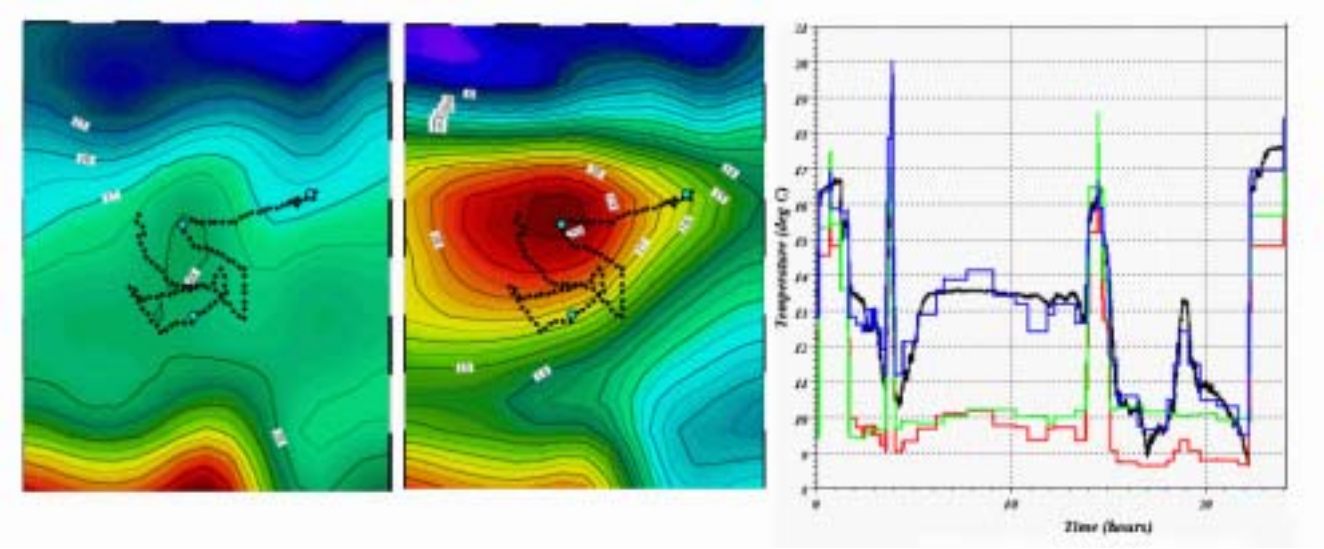

Figure 1 : Initial and final surface temperature fields (left and center panels) with superimposed submarine track projected onto the surface. Right panel shows the raw submarine temperature data over a 24 hour period (black), GDEMV climatology (red), the conventional MODAS first guess field derived using only remote-sensed data (green), and the result of assimilating the temperature using the EOF method (blue).

IMPACT/APPLICATION

The MODAS climatology and synthetic profile algorithms represent a significant advance in operational oceanography. It has become possible to routinely generate nowcasts which are significantly better than climatology virtually anywhere in the world's oceans, from deep water through the littoral, based solely on satellite remote sensed properties. These nowcasts provide an accurate estimate of the temperature and salinity structure which can be further refined by including in situ BT and CTD data where available. As a result, MODAS has become the Navy's preferred source of temperature, salinity and sound speed information about the ocean. The 3-D estimates of temperature and salinity are also now routinely assimilated into global and regional ocean models, providing improved nowcasts and forecasts. Operationally, the availability and accuracy of remote sensed temperatures and heights degrades in shallow water where the time scales decrease. The shallow water improvements task of this project will be addressing these limitations next year.

TRANSITIONS

The present version of MODAS has been operational at the Naval Oceanographic Office for over two years, and is now being delivered to the regional METOC Centers. It is also a component of NITES and is being configured to run in a PC environment as part of IMAT.

RELATED PROJECTS

This project works closely with the 6.4 On Scene Tactical Ocean Forecast Capability project, which delivered an upgraded version of a "light" version of MODAS to the TESS/NITES project. Software

and databases developed by this project are used in the NRL altimetry project. 2-D MODAS fields are assimilated into the Navy Layered Ocean Model (NLOM) and 3-D fields are assimilated into the global implementation of the Navy Coastal Ocean Model (NCOM). The MODAS climatology and synthetic profile algorithms are also used in the NRL/MRY Coupled Ocean Data Assimilation (CODA) project. The MODAS climatology is being used by the ONR 6.2 Coupled Global Air-Sea Model project for their model spinup. MODAS is also a key component in the UW-APL team's contribution to the new ONR project on capturing uncertainty in the environment.

PUBLICATIONS

Fox, D.N., W.J. Teague, C.N. Barron, M.R. Carnes and C.M. Lee, "The Modular Ocean Data Assimilation System (MODAS)". J. Atm. Ocean. Tech (accepted).